

- 1 1. A file distribution system for transfer of data objects comprising:
 - 2 a network of digital data file servers in communication with at least one client
 - 3 system for the transfer of the data objects to the client system;
 - 4 a scheduling apparatus for scheduling said transfer of the data objects from
 - 5 said digital data file servers to the client system, comprising:
 - 6 a file segmenting device to variably and dynamically segment data
 - 7 objects within said digital data file servers dependent upon an
 - 8 available transfer bandwidth, a predicted request loading, and an
 - 9 actual request loading;
 - 10 a client streaming device within said client to begin transfer of a first
 - 11 segment of said data object to said client system such that the
 - 12 client system begins processing of said data object prior to
 - 13 reception of a totality of said first segment;
 - 14 an ordered sequential transfer device to order and sequentially transfer
 - 15 segments of the data object to the client system and to assign a
 - 16 bandwidth to said transfer to prevent simultaneous transfer of all
 - 17 segments of the data object so as to allow transfer of the data
 - 18 objects to multiple systems;
 - 19 a preemption device to cease transfer of a first data object and allow
 - 20 transfer of a second data object that is more urgent than the first
 - 21 data object, whereby said preemption device allows persistent data
 - 22 object transfer of the first digital data object without resending said
 - 23 first digital data object; and

24 a hierarchical caching controller to copy segments of any of the data
25 objects from a central distribution server to any of the network of
26 data file servers, whereby the caching controller selects scheduling
27 of transfers from the central distribution server to any of the network
28 of data file servers or from on data file server within the network of
29 data file servers.

1 2. The file distribution system of claim 1 wherein the transfer at which the network
2 of data file servers has a greater transfer bandwidth than the bandwidth of the
3 client system to accept and process the digital data objects.

1 3. The file distribution system of claim 1 wherein the preemption device executes
2 the steps of:

3 assigning a priority to each of said data objects with in said data file servers;
4 upon request of a segment of a data object by said client, examining whether
5 the transfer bandwidth is sufficient to transfer said requested data object;
6 if said bandwidth is not sufficient, determining if the priority of said requested
7 data object supercedes that of any data object being transferred;
8 if said priority of said requested data object does not supercede that of any
9 data object being transferred, scheduling transfer for said requested data
10 object to a later time;
11 upon completion of the transfer of one of the data objects being transferred,
12 transferring the requested data object;
13 if said priority of said request data object supercedes that of any data object
14 being transferred, ceasing transfer of said data object being transferred

15 having the priority that is superceded by the priority of the requested data
16 object;
17 upon ceasing of said transfer of the data object, transferring the requested
18 data object; and
19 upon completion of the transfer of the requested data object, restarting said
20 data object that had ceased transfer

- 1 4. The file distribution system of claim 1 wherein said scheduling apparatus
2 schedules a request executing the steps of:
3 receiving a request for at least one portion of at least one data object;
4 segmenting by the file segmenting device said data object;
5 caching by said hierarchical caching controller said segments of said data
6 objects within the digital data file servers;
7 determining within said digital data file servers, locations of said cached
8 segments of said requested data object;
9 determining from those locations containing said cached segments those
10 locations within the digital data file servers that are able to transfer said
11 requested segments efficiently;
12 creating a schedule table describing a time at which said requested segments
13 are to be dispatched; and
14 at said time, dispatching said segments to said client systems.
- 1 5. The file distribution system of claim 4 wherein said request for a segment is a pull
2 request initiated by the client server to acquire said segment from the data file
3 servers.

- 1 6. The file distribution system of claim 4 wherein said request for a segment is a
2 push request initiated by a distributor to send said segment to said client server.
- 1 7. The file distribution system of claim 1 wherein the client streaming device
2 controls the flow of packets within one segment being transferred to said client
3 system by the steps of
4 receiving one of said packets;
5 determining if said packet is in correct order relative to previously received
6 packets;
7 if said packet is not in the correct order, requesting a resend of the packet not
8 received in order;
9 buffering said packet received but out of order;
10 receiving a next packet;
11 determining if said next packet is a missing packet not received in order;
12 if said next packet is said missing packet, storing said next packet and any
13 packet received out of order in correct order; and
14 requesting sending of remaining packets of said segment.
- 1 8. The file distribution system of claim 7 wherein said segments of said data objects
2 are transferred using user data gram protocol.
- 1 9. The file distribution system of claim 7 wherein said flow control is implemented as
2 a flow control protocol comprising
3 a send one packet command requesting the data file server containing said
4 segment to send a single packet of said segment;

5 a send packets continuously command requesting the data file server
6 containing said segment to send packet continuously;
7 a send a set of packet command requesting the data file server containing
8 said segment to send a certain number of packets of said segment;
9 a stop sending command requesting said data file server to cease sending
10 said packets;
11 a resend packets command requesting said data file server to stop send
12 current packets and send specified packets;
13 a file size command requesting said data file server to provide said client
14 system with a file size of said segment; and
15 a setup communication command to establish communication parameters
16 including packet size for a fixed packet size and algorithm parameters for
17 a variable packet size.

1 10. The file distribution system of claim 1 wherein said data objects are digital video
2 data objects and said segments are ordered to permit isochronous transfer of
3 said digital video objects to said client systems.

1 11. A video object distribution system for transfer of video data objects comprising:
2 a network of digital data file servers in communication with at least one client
3 system for the transfer of the video data objects to the client system;
4 a scheduling apparatus for scheduling said transfer of the video data objects
5 from said digital data file servers to the client system, comprising:
6 a file segmenting device to variably and dynamically segment video
7 data objects within said digital data file servers dependent upon an

8 available transfer bandwidth, a predicted request loading, and an
9 actual request loading;
10 a client streaming device within said client to begin transfer of a first
11 segment of said video data object to said client system such that
12 the client system begins streaming of said video data object prior to
13 reception of a totality of said first segment;
14 an ordered sequential transfer device to order and sequentially transfer
15 segments of the video data object to the client system and to
16 assign a bandwidth to said transfer to prevent simultaneous
17 transfer of all segments of the video data object so as to allow
18 transfer of the video data objects to multiple systems;
19 a preemption device to cease transfer of a first video data object and
20 allow transfer of a second video data object that is more urgent
21 than the first video data object, whereby said preemption device
22 allows persistent video data object transfer of the first digital video
23 data object without resending said first digital video data object; and
24 a hierarchical caching controller to copy segments of any of the video
25 data objects from a central distribution server to any of the network
26 of data file servers, whereby the caching controller selects
27 scheduling of transfers from the central distribution server to any of
28 the network of data file servers or from on data file server within the
29 network of data file servers.

1 12. The video object distribution system of claim 11 wherein the transfer at which the
2 network of data file servers has a greater transfer bandwidth than the bandwidth
3 of the client system to accept and stream the digital video data objects.

1 13. The video object distribution system of claim 11 wherein the preemption device
2 executes the steps of:

3 assigning a priority to each of said video data objects with in said data file
4 servers;

5 upon request of a segment of a video data object by said client, examining
6 whether the transfer bandwidth is sufficient to transfer said requested
7 video data object;

8 if said bandwidth is not sufficient, determining if the priority of said requested
9 video data object supercedes that of any video data object being
10 transferred;

11 if said priority of said requested video data object does not supercede that of
12 any video data object being transferred, scheduling transfer for said
13 requested video data object to a later time;

14 upon completion of the transfer of one of the video data objects being
15 transferred, transferring the requested video data object;

16 if said priority of said request video data object supercedes that of any video
17 data object being transferred, ceasing transfer of said video data object
18 being transferred having the priority that is superceded by the priority of
19 the requested video data object;

20 upon ceasing of said transfer of the video data object, transferring the
21 requested video data object; and
22 upon completion of the transfer of the requested video data object, restarting
23 said video data object that had ceased transfer

1 14. The video object distribution system of claim 11 wherein said scheduling
2 apparatus schedules a request executing the steps of:
3 receiving a request for at least one portion of at least one video data object;
4 segmenting by the file segmenting device said video data object;
5 caching by said hierarchical caching controller said segments of said video
6 data objects within the digital data file servers;
7 determining within said digital data file servers, locations of said cached
8 segments of said requested video data object;
9 determining from those locations containing said cached segments those
10 locations within the digital data file servers that are able to transfer said
11 requested segments efficiently;
12 creating a schedule table describing a time at which said requested segments
13 are to be dispatched; and
14 at said time, dispatching said segments to said client systems.

1 15. The video object distribution system of claim 14 wherein said request for a
2 segment is a pull request initiated by the client server to acquire said segment
3 from the data file servers.

- 1 16. The video object distribution system of claim 14 wherein said request for a
2 segment is a push request initiated by a distributor to send said segment to said
3 client server.
- 1 17. The video object distribution system of claim 11 wherein the client streaming
2 device controls the flow of packets within one segment being transferred to said
3 client system by the steps of:
4 receiving one of said packets;
5 determining if said packet is in correct order relative to previously received
6 packets;
7 if said packet is not in the correct order, requesting a resend of the packet not
8 received in order;
9 buffering said packet received but out of order;
10 receiving a next packet;
11 determining if said next packet is a missing packet not received in order;
12 if said next packet is said missing packet, storing said next packet and any
13 packet received out of order in correct order; and
14 requesting sending of remaining packets of said segment.
- 1 18. The video object distribution system of claim 17 wherein said segments of said
2 video data objects are transferred using user data gram protocol.
- 1 19. The video object distribution system of claim 17 wherein said flow control is
2 implemented as a flow control protocol comprising
3 a send one packet command requesting the data file server containing said
4 segment to send a single packet of said segment;

- 5 a send packets continuously command requesting the data file server
6 containing said segment to send packet continuously;
7 a send a set of packet command requesting the data file server containing
8 said segment to send a certain number of packets of said segment;
9 a stop sending command requesting said data file server to cease sending
10 said packets;
11 a resend packets command requesting said data file server to stop send
12 current packets and send specified packets;
13 a file size command requesting said data file server to provide said client
14 system with a file size of said segment; and
15 a setup communication command to establish communication parameters
16 including packet size for a fixed packet size and algorithm parameters for
17 a variable packet size.
- 1 20. The video object distribution system of claim 11 wherein said video data objects
2 segments are ordered to permit isochronous transfer of said digital video objects
3 to said client systems.